
Contents

Foreword	xi
Philippe GUILLERMAIN and François SCHLOSSER	
Entrepreneur's Tribune: Geotechnics is at the Heart of Our Projects	xiii
Pascal LEMOINE and Eric DURAND	
Preface	xv
Acknowledgments	xxi
Symbols and Notations	xxiii
Introduction	lvii
Chapter 1. Active and Passive Earth Pressures: Earth Retaining Structures	1
1.1. Active and passive earth pressures	1
1.1.1. Introduction	1
1.1.2. State of soils at rest	2
1.1.3. Active earth pressure in the soil	4
1.1.4. Passive earth pressure in the soil	8
1.1.5. Active and passive earth pressure forces	10

1.1.6. Active–passive pressure and back passive pressure: choice of incline	13
1.1.7. Active–passive earth pressures: specific cases	16
1.1.8. Effect of overloads	19
1.1.9. French practice	23
1.2. Behavior and sizing of earth retaining structures	25
1.2.1. Introduction: designing retaining structures	25
1.2.2. Classes of earth retaining structures	25
1.2.3. Limit conditions	27
1.2.4. History and path of the stresses	28
1.2.5. Behavior of rigid and flexible walls	31
1.3. Designing approaches	32
1.3.1. Classic failure analysis	33
1.3.2. Reaction coefficient method	34
1.3.3. Finite elements calculations	34
1.4. Method based on the reaction coefficient	35
1.4.1. Principle of the method	35
1.4.2. Soil/retaining structure reaction curve	36
1.4.3. Resolution method	39
1.4.4. Approaches for evaluating the reaction coefficient	40
1.5. The specific case of reinforced excavations	43
1.5.1. The principle of reinforcement	43
1.5.2. Horizontal stresses distribution diagrams	44
1.6. Subgrade stability	46
1.6.1. “Solid piping”	46
1.6.2. “Boiling” phenomenon	48
1.7. Applications	49
1.7.1. “Gravity” earth-retaining wall in a homogeneous soil mass	49
1.7.2. Study of a sheet piling using a classic failure analysis	61
1.7.3. Study of an advance shoring excavation	70
1.7.4. Project for a retaining diaphragm anchored by active tie rods	78
1.8. Incidents: they can happen quickly!	103
1.8.1. Case of a sheet piling fixed in chalk	103
1.8.2. Retaining diaphragm walls with tie rods and anchored in a substratum	104
1.8.3. Alternate pass shell technique	105
1.9. Appendices	107
1.9.1. Appendix 1: Ground friction/strut sealing	107
1.9.2. Appendix 2: Steel reinforcement of continuous walls	113
1.9.3. Appendix 3: Stability of the tie rod mass (Kranz approach)	115
1.9.4. Appendix 4: Stability and comparison of approaches in earthquake calculation for retaining gravity walls	116
1.10. References	119

Chapter 2. Soil Reinforcement and Improvement	123
2.1. Overview	123
2.1.1. Introduction	123
2.1.2. Historical and geographic context of the development of soil improvement techniques	125
2.1.3. The field and limits of the application of the different techniques	128
2.2. Reinforced Earth.	131
2.2.1. Process	131
2.2.2. Construction method and displacement field.	131
2.2.3. Displacement field	132
2.2.4. The surface of potential failure and tensile stresses in the reinforcement	133
2.2.5. Location and distribution of maximum tension in an RE wall	135
2.2.6. Friction between the soil and the RE reinforcement	136
2.2.7. Designing RE structures.	137
2.2.8. The behavior of Reinforced Earth under triaxial shear testing	140
2.3. In situ soil nailing	141
2.3.1. The principles of nailing.	141
2.3.2. The behavior of nailed walls	143
2.3.3. The interaction between the soil and the rod: the forces occurring around the rigid rod	145
2.3.4. The dimensions of the structures made from nailed earth	147
2.4. Soil reinforcement with micropiles	156
2.4.1. The principle of micropiles	156
2.4.2. Types of forces on micropiles and an assessment of possible actions	156
2.4.3. Theoretical study of an isolated micropile under centered axial load	158
2.4.4. An isolated micropile that causes a lateral reaction in the soil	160
2.4.5. Buckling of a micropile embedded into the soil	162
2.4.6. The effect of a group or a network: efficiency coefficient (k_{cf})	163
2.4.7. Designing structures reinforced by micropiles.	165
2.4.8. The justification of Eurocode micropile	168
2.5. Applications	170
2.5.1. The mixed structure: Reinforced Earth and nailed walls	170
2.5.2. Construction crane on top of a group of micropiles.	182
2.5.3. Comparing some French guidelines	189
2.6. Other techniques of in situ soil improvement.	194
2.6.1. Compaction through vibration	194
2.6.2. Dynamic compaction.	198

2.6.3. Soil–cement mortar columns carried out by jet grouting	200
2.6.4. Stone columns	203
2.6.5. In situ soil improvement through the use of rigid inclusions	210
2.6.6. Deep compaction/solid injection	213
2.6.7. Mixing the soil with a binder: the lime–cement column	216
2.6.8. Consolidation by pre-loading	218
2.6.9. Vacuum consolidation	222
2.6.10. Other techniques	223
2.6.11. Classical injections	224
2.6.12. Soil freezing	226
2.6.13. Some economic data	228
2.7. Approaches to design	231
2.8. Applications	232
2.8.1. The study of embankment on stone columns	232
2.8.2. Study of an industrial paving on vertical rigid inclusions topped by stone columns	237
2.8.3. Reduction of the risk of liquefaction with the vibro stone columns	242
2.8.4. The behavior of rigid inclusions under general rafts	246
2.9. A what not to do!	249
2.9.1. Case 1: building on stone columns	249
2.9.2. Data relative to the soil in case 1	249
2.9.3. Improving soils with stone columns (case 1)	250
2.9.4. Case 2: store with semi-rigid inclusions	253
2.9.5. Others (“school case”)	253
2.10. Appendices	253
2.10.1. Appendix 1: Sizing chart of the lateral limit friction between the soil/nail (Clouterre 1991)	253
2.10.2. Appendix 2: Practical sizing charts of stone columns	255
2.10.3. Appendix 3: Sizing charts for the global safety coefficient of embankments on soil treated with stone columns	258
2.10.4. Appendix 4: Structural verification of the support plate and the tie rod beams	262
2.11. References	265
Chapter 3. Underground Works: Convergence–Confinement Method	273
3.1. Introduction	273
3.1.1. Underground cavities	274
3.1.2. Definition of a tunnel and its supporting structures	275

3.2. Failure area at the vault of the tunnel and forces	276
3.2.1. Failure area at the vault of the tunnel	276
3.2.2. Forces on the supporting structures	277
3.3. Displacement of the receiving terrains	278
3.3.1. Convergence of tunnels and extrusion.	278
3.3.2. Surface displacement (“subsidence”)	279
3.4. Mechanic behavior of tunnels	280
3.4.1. “Convergence–confinement” method	281
3.4.2. Simple methodology for estimating settlement	283
3.5. Dig methods and retaining structure types.	286
3.5.1. Dig methods	286
3.5.2. Requirements and support types	286
3.6. Practical applications	288
3.6.1. Estimating the settlements empirically	288
3.6.2. Some practical results relating to surface settlement	295
3.6.3. Modeling with plane deformations.	297
3.7. References	299

French, European and ISO Standards in the Field of Geotechnics	303
---	------------

Index	335
------------------------	------------

Summaries of Other Volumes.	337
--	------------